Final Report

A project under the Canada New Brunswick Conservation and Renewable Energy Demonstration Program

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FOREST HARVESTING RESIDUES AS FUEL

FRASER INC.

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69

Canada/New Brunswick Conservation and Renewable Energy Demonstration Program

The Conservation and Renewable Energy Demonstration Program Program is administered in New Brunswick by the Energy Secretariat and managed jointly with Energy, Mines and Resources Canada. The Program is designed to help demonstrate promising conservation and renewable energy technologies, to develop public awareness and understanding of these technologies, and to create employment in new or existing industries.

Through over 100 demonstration projects in New Brunswick, a wide variety of conservation and renewable energy technologies have proven to be technically sound and economically attractive. These demonstration projects should now provide a catalyst for commercialization and lead to widespread adoption of many of these proven technologies.

This final report is based on a project which was financially supported by the Energy Demonstration Program. For further information on other demonstration projects funded in New Brunswick under this program, contact:

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Le succès ainsi rencontré encourage la commercialisation des procédés les plus accessibles. Cela entraînerait certes l'adoption d'un grand nombre de ces techniques par les propriétaires de domiciles et par l'industrie privée.

Ce rapport final est basé sur un projet qui a reçu une aide financière du Programme de démonstration. Pour de plus amples renseignements, communiquez avec la:

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EXECUTIVE SUMMARY

HARDWOOD FULL TREE CHIPPING

A hardwood full tree harvesting and chipping project was conducted from August to November 1983 on the Fraser Inc. Restigouche-Tobique Crown License.

The objective of the trial was to evaluate, on an industrial scale, appropriate equipment, techniques, and costs of removing and processing non-marketable residual full tree hardwood into biomass fuel.

A 22" capacity Morbark Chiparvester processed and discharged full tree hardwood chips into standard highway chip vans. A total of 4557.54 green tonnes of biomass were produced and delivered 166 km. to the Fraser Inc. Atholville Pulpmill at a cost of $43.85/tonne. Chipper productivity averaged 26.4 tonnes per hour, but varied from 13.2 to 46.2. The main factor affecting chipper productivity was tree form, with large tops requiring manual delimbing to infeed. Preparation of tops at the felling site and/or a larger capacity chipper would have reduced the problem. The average van load was 30.8 tonnes, at an average moisture content on delivery of 40%.

Hardwood Full Tree chips as evaluated in a handling and burning trial at Atholville were considered a superior fuel to currently utilized softwood sawmill residues.

The hardwood chipping project was considered a success with the objectives being met, and the discovery of operational techniques to improve production and costs on similar future operations.

SOFTWOOD RESIDUE PROCESSING

Spruce and fir limbs and tops resulting from full tree delimbing operations were processed from July 16 to August 10, 1984 on Fraser Inc. Freehold land, approximately 10 miles from St. Quentin, N.B.

The objective of the trial was to evaluate, on an industrial scale, appropriate equipment, techniques, and costs of processing roadside softwood logging residue into biomass fuel.

A Morbark Super Beaver Chipper with powered infeed conveyor processed and discharged processed softwood residue into standard highway chip vans (14 meter long). A total of 57.05 tonnes of biomass were produced and delivered 95 km. to Atholville at a cost of $236.95/tonne. Chipper productivity averaged 1.2 tonnes per hour, and the average van load weighed 14.3 tonnes.

Serious infeed and discharge problems were experienced with the system, and the project was terminated after 4 operating weeks. The original plan called for a production of 3200 tonnes over a 3 month period.

In spite of the low production, the project was considered successful in that the system was fully evaluated, modifications were made on site, and further modifications are suggested to improve the unit.

As a result of the erratic deliveries and low volume to the mill, neither moisture content samples or a handling and burning trial could be conducted.

SOMMAIRE-RECOMMANDATION

DECHIQUETAGE DES ARBRES ENTIERS DE BOIS DUR

Un projet d'exploitation et de déchiquetage d'arbres entiers de bois dur a été tenté de août à novembre 1983 sur les terres de la Couronne de Restigouche-Tobique concédées à Fraser Inc.

Cette expérience avait pour but d'évaluer, à l'échelle industrielle, l'outillage et les techniques appropriées ainsi que les coûts pour la récolte des arbres entiers de bois dur résiduel non commercialisable et leur transformation en biomasse combustible.

Un Chiparvester Morbark d'une capacité de 22" a été utilisé pour transformer les arbres entiers de bois dur en copeaux et déverser ces derniers dans des fourgonnettes de livraison standard. Au total, 4557,54 tonnes de biomasse humide ont été produites et livrées sur une distance de 166 km à l'usine de pâtes et papier de Fraser Inc. à Atholville, au coût de 43,85 $/tonne. La productivité moyenne de la déchiqueteuse était de 26,4 tonnes l'heure, mais elle variait de 13,2 à 46,2 tonnes/heure. Le principal facteur influant sur ces résultats était la forme des arbres; en effet, les cimes plutôt fournies devaient être ébranchées manuellement avant de procéder à leur déchiquetage. On aurait pu réduire ce problème en préparant les cimes sur les lieux mêmes de l'abattage ou en utilisant une déchiqueteuse de capacité supérieure. La charge moyenne des fourgonnettes était de 30,8 tonnes, à une teneur en humidité moyenne de 40 % au moment de la livraison.

L'évaluation des copeaux de bois dur récoltés en arbres entiers lors d'un essai de traitement et de combustion à Atholville a révélé qu'ils constituaient un combustible supérieur aux résidus de sciage de bois mou normalement utilisés.

Le projet de déchiquetage de bois dur a donc été un succès puisque l'objectif a été atteint et qu'on a fait la découverte de techniques fonctionnelles permettant d'améliorer la production et le prix de revient lors de futures expériences semblables.

TRANSFORMATION DE RESIDUS DE BOIS MOU

Du 16 juillet au 10 août 1984, on transforma des branches et des cimes d'épinette et de sapin provenant d'opérations d'ébranchage d'arbres entiers sur les terres à tenure libre de Fraser Inc., à environ 10 milles de Saint-Quentin (N.-B.)

Cette expérience avait pour but d'évaluer, à l'échelle industrielle, l'outillage et les techniques appropriées ainsi que les coûts pour la transformation au bord du chemin des résidus de débusquage de bois mous en biomasse combustible.

Une déchiqueteuse Super Beaver Morbark munie d'un mécanisme d'alimentation automatique était utilisée pour transformer les résidus de bois mou en copeaux et les déverser dans des fourgonnettes de livraison standard (d'une longuer de 14 mètres). Au total,

57,05 tonnes de biomasse humide ont été produites et livrées sur une distance de 95 km à l'usine d'Atholville, au coût de 236,95 $/tonne. La productivité moyenne de la déchiqueteuse était de 1,2 tonne l'heure et la charge moyenne des fourgonnettes était de 14,3 tonnes.

De graves problèmes d'alimentation et de déversement se sont produits et le projet fut interrompu au bout de 4 semaines d'exploitation. Les prévisions originales étaient de 3200 tonnes de copeaux sur une période de 3 mois.

Malgré cette faible production, le projet a quand même été utile puisqu'il a permis d'évaluer pleinement le système, que des modifications ont été apportées sur place et que d'autres suggestions ont été faites pour l'amélioration de l'appareil.

Quant au résultat des livraisons irrégulières à l'usine et du faible volume, il ne fut possible de procéder ni à un échantillonnage pour évaluer la teneur en humidité ni à un essai de traitement et de combustion des copeaux.

FIGURE 1 - Woodlands Biomass Chipping Locations (1983 and 1984)

INTRODUCTION

Two distinct phases of the biomass project were implemented, and these will be discussed separately in terms of objectives, equipment, productivity, problems, and recommendations.

The first phase, hardwood full tree harvesting and chipping, was conducted from August to November of 1983.

The objective of the hardwood phase was to process non-marketable hardwood residue from a softwood logging site, to determine accurate cost data on the operation, as well as to evaluate the logistics and appropriate equipment for an industrial scale operation.

Approximately 30% of Fraser's annual harvest for spruce and fir is conducted in mixedwood stands. Sawlogs comprise approximately 15% (varies from 10 to 20%) of the hardwood tree length volume, with the remainder being pulpwood quality material. Unfortunately the market for poor quality hardwood material is not well developed. Secondly, the distance of Edmundston District harvest operations from existing hardwood plants make roundwood transport too expensive.

In order to properly site prepare and establish a softwood plantation, the majority of non-marketable residual hardwood trees must be removed. The objective being to clean the site such that proper coverage with site preparation equipment can be achieved. The processing of residual full-tree hardwood into biomass fuel presents a reasonable alternative to a viable roundwood pulpwood market. By removing, and processing in full tree form, biomass recovery is increased, and large tops, which impede site preparation, are removed from the harvest area.

Fraser Inc's Atholville and Edmundston Pulpmills both have biomass boilers which operate primarily on locally purchased softwood sawmill residue, with Edmundston also using bark from the roundwood mill debarkers. A surplus of sawmill residue is currently available at low prices; however as municipal and industrial demands increase, shortages may occur. Potential markets for Fraser produced forest biomass are the two pulpmills as well as a proposed thermal electric power generating plant in the State of Maine. In 1983 however, all hardwood full tree chips were delivered to the Atholville Pulpmill.

The value of a green metric tonne (tonne) hardwood full-tree chips at 50% moisture content in terms of oil displaced is calculated at approximately $40.

The hardwood chipping project was conducted on the Restigouche-Tobique License, near the South Branch Kedgwick River.

The second phase, softwood logging residue chipping, was also initiated in 1983, but due to unavailable processing equipment, was postponed until 1984. Softwood chipping was conducted from July 16 to August 10, 1984.

Approximately 25% of the Fraser annual harvest is in Full-Tree form to roadside, which is mechanically delimbed leaving large volumes (estimated 50 000 m^3 per year) of Spruce and Fir limbs and tops. These accumulations impede plantation establishment or natural regeneration, are a potential fire hazard, and are aesthetically disturbing to the public. In addition, if appropriate processing equipment and methods can be developed, an additional renewable source of fuel can be tapped. Furthermore, Licensees operating in the Province of New Brunswick are required under the requirements in the Forest Management Manual (Anon, 1984) to burn or remove excessive slash piles and high windrows in order to facilitate either natural or artificial regeneration.

Alternatives to processing the softwood residue into fuel are broadcast burning in early spring or late fall, and bulldozing of slash into piles to limit area covered with the material.

Performance objectives of the softwood residue phase are as per hardwood chipping.

The field trials were conducted on Fraser Freehold land approximately 10 miles south of St. Quentin. Markets for the processed softwood residue were the Atholville pulpmill in 1984. However, should an operational system be developed, the Edmundston pulpmill and the Northern Maine thermal power project are potential markets.

TECHNICAL DESCRIPTION

HARDWOOD FULL TREE CHIPPING

The hardwood project was conducted in two mixedwood harvest blocks on the Restigouche-Tobique License in the vicinity of the South Branch Kedgwick River.

Spruce and Fir timber was harvested and transported to roadside with a Koehring Feller Forwarder and delimbed with a Logma boom delimber. Softwood harvesting and delimbing was conducted in the summer of 1983, hardwood harvesting from mid-August to mid-October, and chipping from October 4 to November 22.

Forty-nine hectares were harvested in block 510 0007 83 (7) and 112 in block 510 0008 83 (8). A total of 5336 m^3 of spruce and fir logs and pulpwood, 2008 m^3 of hardwood logs and chipwood, and 19 m^3 of cedar were harvested from block 7. A total of 11 862 m^3 of spruce and fir logs and pulpwood, 3 163 m^3 of hardwood logs and chipwood, and 4 m^3 of cedar were harvested from block 8.

The project may be divided into the following phases:

1) harvest full tree softwood, delimb, slash and haul to provide room for hardwood piling;

2) harvest full tree hardwood;

3) remove hardwood logs;

4) chip remaining low quality hardwood and transport to Atholville Mill.

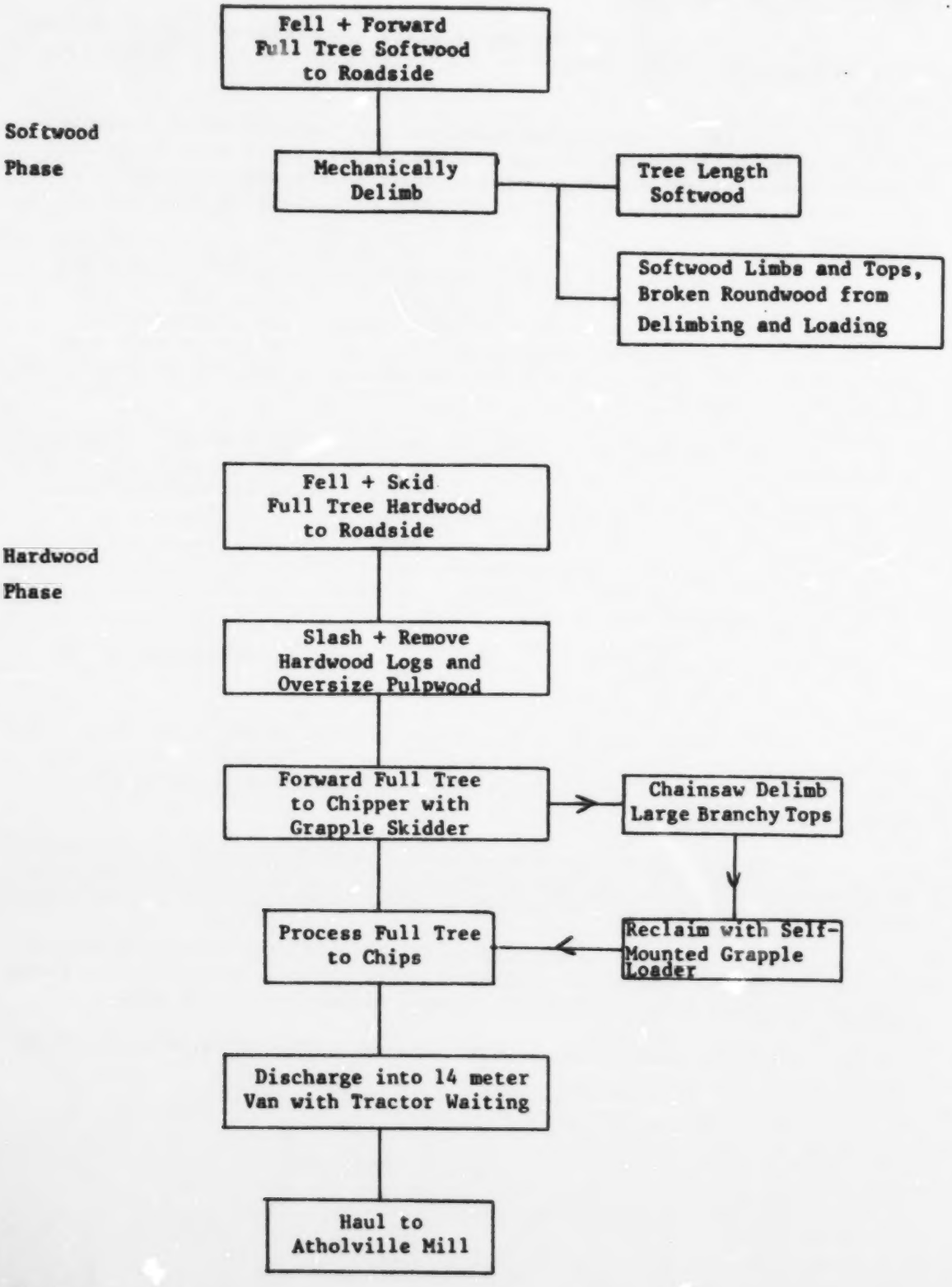
The hardwood component was harvested by a two-man crew (feller and skidder operator). After scaling, the hardwood was bucked by a three-man crew (2 buckers, 1 operator) using a MOR-BELL logger (small three-wheeled, overhead grapple loader).

Hardwood full trees were chipped by a MORBARK Model 22 (22 inch capacity) chipper, equipped with a 600 hp. diesel engine. A large grapple skidder forwarded the full trees from roadside to the trailer mounted chipper.

The chipping operation was performed by Wingus Inc., a firm from East Angus, Québec, and chip transportation contracted to Restigouche Transport of Kedgwick, N. B. Three axle 14 meter highway vans were used.

Two chainsaw operators were required to delimb large topped hardwood.

FIGURE 2 - HARDWOOD FULL TREE HARVESTING AND CHIPPING FLOW CHART


Softwood Phase
Fell + Forward Full Tree Softwood to Roadside
Mechanically Delimb
Tree Length Softwood
Softwood Limbs and Tops, Broken Roundwood from Delimbing and Loading
Hardwood Phase
Fell + Skid Full Tree Hardwood to Roadside
Slash + Remove Hardwood Logs and Oversize Pulpwood
Forward Full Tree to Chipper with Grapple Skidder
Chainsaw Delimb Large Branchy Tops
Reclaim with Self-Mounted Grapple Loader
Process Full Tree to Chips
Discharge into 14 meter Van with Tractor Waiting
Haul to Atholville Mill

SOFTWOOD RESIDUE PROCESSING

The softwood phase was conducted in a post-harvest spruce and fir type block on Fraser freehold approximately 10 miles south of St. Quentin.

Spruce and fir timber was harvested and transported to roadside with a Koehring Feller Forwarder and delimbed with Logma and Harricana delimbers. Harvesting and delimbing was conducted in the summer of 1983, and wood was removed in the fall.

One hundred and fifty-three hectares were harvested in block F10 0012 83. A total of 22 723 m^3 of spruce and fir logs and pulpwood, 5 m^3 of hardwood logs and pulpwood, and 1 778 m^3 of cedar were harvested from block 12. An estimated 7 000 m^3 of spruce and fir limbs and tops were available for processing.

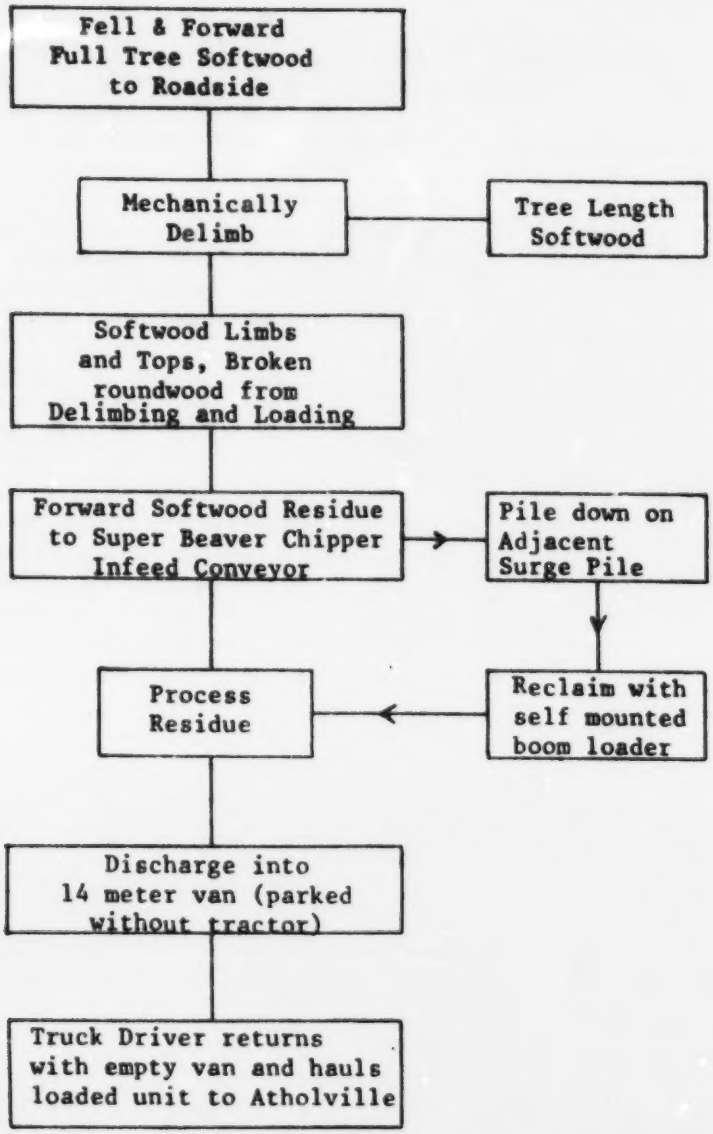
A MORBARK Super Beaver chipper equipped with a 195 hp. diesel engine was rented from Canadian Morbark in North Bay, Ontario. A powered conveyor infeed system was designed and built by Morbark to convert the roundwood chipper to a unit capable of processing softwood limbs and tops.

Softwood residue was forwarded to the chipping unit with a MOR-BELL logger and piled directly onto the conveyor, or on the adjacent surge pile. A 3.2 meter reach boom loader attached to the chipper moved material from the surge pile to the infeed conveyor.

Processed material was discharged into 14 meter three-axle highway vans contracted by Restigouche Transport Company of Kedgwick, N. B. One van was parked on site, and when the driver returned to remove the loaded van, he would install an empty unit.

Manpower utilized were one chipper operator, one loader operator, and one foreman.

FIGURE 3 - SOFTWOOD RESIDUE PROCESSING FLOW CHART


Fell & Forward Full Tree Softwood to Roadside
Mechanically Delimb
Tree Length Softwood
Softwood Limbs and Tops, Broken roundwood from Delimbing and Loading
Forward Softwood Residue to Super Beaver Chipper Infeed Conveyor
Pile down on Adjacent Surge Pile
Process Residue
Reclaim with self mounted boom loader
Discharge into 14 meter van (parked without tractor)
Truck Driver returns with empty van and hauls loaded unit to Atholville

OBSERVATIONS DURING INSTALLATION AND MONITORING

HARDWOOD FULL TREE CHIPPING

A total of 148 vans were produced for 4 557.54 tonnes for an average 30.8 tonnes per van. The average loading time was 70 minutes for an average chipper productivity of 26.4 tonnes per hour.

However, loading time was variable from 40 to 130 minutes (46.2 to 13.2 tonnes per hour), which was primarily a function of tree form.

The best production occurred in concentrations of white birch, the crowns of which are thin and pass easily through the chipper throat. Production slowed considerably in concentrations of mature to overmature yellow birch, the crowns of which are heavily branched, and did not feed smoothly into the chipper. Two men were assigned to delimb the large topped trees piled down by the chipper operator on either side of the machine. In spite of the additional delimbing manpower, the chipper could not always be fully charged, and idle time occurred. In addition, hardwood tops were removed whole, and transported to a bucker for limbing. The loader then piled the branches. This method was abandoned due to the difficulty of handling the large hardwood tops with the small Morbell loader.

Two possible solutions to the problem are:

1. Utilize a larger capacity (30 inch) chipper, or a direct drive chipper which provides more torque on the chipping disc.

2. Prepare the large crowns at the felling area. A contractor currently working on the Fraser Inc. License is partially cutting through the large limbs at the crown base. The full tree is forwarded, intact, with a grapple skidder to the chipper. As the crown enters the powered infeed rollers, the branches collapse, and plugs rarely occur.

   Because the chipping unit determines the productivity of the entire system, it is essential that non productive time be minimized.

Hardwood trees less than 18 cm. butt diameter were left standing. Trees of this size were not considered to limit site preparation and plantation establishment. As a result of the diameter-based wage rate structure, harvesting hardwood trees of this size would have significantly increased the roadside cost of full tree hardwood.

A strip cruise was conducted on blocks 7 and 8 and the results are discussed below:

The total volume of trees up to 18 cm. butt diameter, standing on the 166 ha. area was 502 m^3 or 3 m^3/ha. (less than .5 cunits per acre)

Hardwood volumes harvested are described in Table 1, page 11.

TABLE 1 - HARDWOOD PRODUCTION (m^3) USING N.B.D.N.R. TREE LENGTH VOLUME TABLE

Total Volume Harvested:

Full Tree		5 030.40	(based on tree length butt scale)
Tree Length		143.25	
		5 173.65	
Sawlogs	891.58		
Log Rejects	13.30		
Spoolwood	4.83		
Pulpwood	91.08		
Volume Available for Chipping		4 172.86	
Less: Estimated Volume Unprocessed		400.00	
Volume Chipped			3 772.86 m^3

The Department of Natural Resources tree length volume table is considered to overestimate the true volume of tree length hardwood on the Fraser Inc. License. Using a volume table derived from studies conducted on Fraser Limits in 1981, the following results were obtained:

Mixed Hardwood	Vol.(m^3)	
Full Tree	3 840.25	(based on tree length butt scale)
Tree Length	109.36	
Total	3 949.61	
Less:		
Sawlogs	891.58	
Log Rejects	13.30	
Spoolwood	4.83	
Pulpwood	91.08	
Total	1 000.79	
Volume available for chipping	2 948.82	
Less: estimated volume unprocessed	305.36	
Volume Chipped (Tree Length)		2 643.46 m^3

Volume of Branches and Bark

Volume in branch and bark material is calculated under the assumption that one cubic meter of roundwood hardwood is equivalent to .96 metric tonnes of chips at 45% moisture content.

Then; Total volume chipped = tree length + branches

branches chipped = total volume - tree length

$$\text{Total Volume Chipped} = \frac{\text{tonnes produced}}{.96 \text{ tonnes/m}^3}$$

$$= \frac{4\ 557.54}{.96} = 4\ 747.44\ \text{m}^3$$

and: Branches and bark chipped = 4 747.44 - 2 643.46

= 2 103.98 m^3

In other words, branches and bark represented 44.3% of the total volume chipped (2 643.46 m^3) after removal of marketable roundwood products.

$$\frac{2\ 103.98}{2\ 103.98 + 2\ 643.46} \times 100 = 44.3\%$$

OBSERVATIONS DURING INSTALLATION AND MONITORING

SOFTWOOD RESIDUE PROCESSING

A total of 4 van loads were produced for 57.05 tonnes or an average of 14.3 tonnes per van. The average loading time was 11.9 hours for a chipper productivity of 1.2 tonnes per hour.

A planned productivity of 8 - 10 tonnes per hour was anticipated by the supplier and by Fraser Inc.

A number of design factors limited production and will be discussed below. The residue from the spruce and fir delimbing operation consisted of unorganized branches and tops (10 cm maximum diameter) and a minor quantity of broken roundwood pieces from 10 to 25 cm in diameter to 4 meters long).

Material Infeed Limitations

1. Chipper Mounted Boom Loader

The chipper loader (3.2 m. long) was equipped with a non-pivoting grapple device. This limited the operator's ability to position tops and broken pieces parallel to the infeed conveyor. As a result, pieces frequently turned crosswise on the conveyor or blocked the side feed wheels. The MOR-BELL loader, equipped with an efficient pivoting grapple was often utilized to feed the conveyor directly from the slash piles. This resulted in non-productive time between cycles to the pile.

2. Infeed Conveyor

The powered infeed conveyor (live surface approximately .75 x 2.2 meters) was attached to the 1860 cm^2 spout opening of the chipper. A horizontal, powered, studded feed roller (approximately 50 cm diameter x 600 cm) was mounted on the chipper and could be depressed onto the material to aid in feeding.

Initially the live conveyor surface was relatively smooth (Appendix II photo) and consisted of two parallel chains of 20 cm links. After operating 15 hours, it was apparent that residue was slipping on the conveyor, and not feeding properly. The unit was removed and 120 round high carbon steel bars (2.54 x 5 cm) were welded onto the chains. The bottom steel plate was lowered to enable passage of the cleats. Traction on the residue was improved and productivity increased from approximately 1 tonne per hour to 2.

3. Transfer of Material from Conveyor to Chipping Disc

From the spout end of the conveyor to the chipping disc is a 1 meter long unpowered surface. Tops and roundwood pieces were pulled over this surface by the feed rollers. Clumps of branches (estimated 80% of unprocessed volume) tended to plug in this region. Vertical and horizontal feed rollers applied traction to the outside of the clumps only and plugs of branches frequently occurred.

Discharge of Processed Material

The 132 cm diameter chipping disc is equipped with 4 fan blades which propel the processed material through the discharge chute into the van. With a maximum engine R.P.M. of 2800, the disc turns at 850 R.P.M. After several operating hours, it was observed that chips from the roundwood and tops were discharging to the end of the 14 meter van, but that limb, foliage and bark material were being propelled only 3 to 8 meters. Strips of 1 cm steel were welded onto the fan blades to increase the blowing power, and engine R.P.M. was increased to 3000 for an estimated 900 R.P.M. on the disc. This modification did not significantly improve the discharge distance, and as the short discharge pile of lighter material became larger vans could only be partially filled (Average actual weight of 14.3 tonnes versus a possible 25 to 30 tonnes).

A secondary blowing system (booster fan) on the discharge chute may have improved the problem, which is referred to as wind stratification common to air discharge of variable weight residue material.

Plugging of the discharge chute frequently occurred and appeared to be the result of three main factors:

a) High moisture content (estimated 55%) of one year old residue.

b) Square discharge chute in which branch pieces (20 - 30 cm long) tended to turn crosswise and cause a plug.

c) Insufficient discharge power.

A square chute with a hydraulically powered booster fan or a conveyor system is recommended to improve discharge of the variable weight material that results from processing softwood residue.

Limitations of the Material

Two types of delimbers are currently in use on Fraser Inc. operations. One type delimbs the tree from the top which results in a relatively even layer of branches (approximately .5 to 1 meter deep by 10 meters wide along the logging road). The other type delimbs from the butt, and branches remain in piles up to 2.5 meters high and 10 meters apart.

It was observed that material reclaimed from the large piles was extremely wet and discharge chute plugging was frequent with this material (approximately each 2 operating hours). On the other hand, moisture content was less in the low piled material and production was improved.

After three vans were loaded from one year old residue, equipment was relocated to material delimbed two weeks previously. Infeed problems still persisted and wind separation of lighter and heavier chips was still evident. However, plugging of the discharge chute was less frequent. A series of minor mechanical problems prevented determination of production, yet it was estimated at 3 tonnes per hour.

PROJECT COST ACCOUNTING
TABLE 2 - FRASER INC., SUMMARY OF COSTS - HARDWOOD BIOMASS PROJECT, FOR THE PERIOD ENDED NOVEMBER 30, 1983

FULL TREE	m^3	$	$/m^3$
ROADSIDE COST			
Total Roadside Cost before Overhead	3 772	$ 45,114	$11.96
OVERHEAD COST		$ 27,610	$ 7.32
TOTAL COST BEFORE CHIPPING AND TRUCKING	3 772	$ 72,724	$19.28
	Green Tonnes	$	$/tonne
Total Hardwood Cost as above	4 558	$ 72,724	$15.96
CHIPPING COST		$ 63,290	$13.89
CHIP TRANSPORTATION		$ 63,806	$14.00
TOTAL COST DELIVERED TO ATHOLVILLE	4 558	$199,820	$43.85

N.L. Martin
December 21, 1983

TABLE 3 - FRASER INC., SUMMARY OF COSTS - SPRUCE & FIR BIOMASS PROJECT FOR THE PERIOD JULY 16 TO AUGUST 10, 1984

	Tonne	$	$/Tonne
ROADSIDE COST (BRANCHES)	57	-	-
CHIPPING COST		$ 4,110.42	$72.13
LABOUR COST		$ 4,332.19	$76.00
OTHER COSTS (Men & Foreman Transportation, Chipper Modifications & Repairs, Benefits on wages)		$ 4,038.71	$70.85
CHIP TRANSPORTATION		$ 1,025.00	$17.97
TOTAL COST DELIVERED TO ATHOLVILLE	57	$13,506.32	$236.95

N.L. Martin
November 26, 1984

COST-BENEFIT ANALYSIS

HARDWOOD FULL TREE CHIPPING

Total cost of the project in 1983 dollars as reported on claim number 1, project #2057 was $199,820.00.

Total net cost to Fraser Inc. is $79,820 for a cost per delivered tonne of $17.54 (before credit for fuel).

The energy equivalent fuel value for hardwood full tree chips as compared to oil is shown in Appendix IV. This comparison does not consider the relative capital and operating costs associated with biomass or oil burning.

A number of silvicultural benefits which result from removal of non-marketable hardwood from softwood harvesting areas can be quantified and are discussed:

1. Full tree softwood logging and removal of residual hardwood trees permits the establishment, on inadequately naturally regenerated areas, of softwood plantations. The long term wood supply of Fraser Inc. and most other Licensees in New Brunswick depends critically on the establishment and maintenance of softwood plantations in harvest areas that do not regenerate naturally.

2. Residual hardwood removal results in improved conditions for site preparation. Normally, following non-marketable residual removal, site preparation can be conducted with a lighter patch or disc scarifying tool as opposed to a heavy plow and bulldozer. Net savings with the light implements pulled by a skidder are $50/hectare. Expanding this over the 161 hectare experimental area, a savings of $8,050.00, or $1.77/tonne are realized.

3. Site preparation with lighter implements results in lower % mineral soil exposure. As a result, competition from shrubs and undesirable woody species is reduced, and on some sites only one application of selective herbicide will be required to release the young softwoods. Frequently, on sites with higher mineral soil exposure, competition is more severe, and 2 applications of herbicide are required within 5 years of establishment.

   Net savings per hectare, for the trial area assuming 50% of the area would require 1 herbicide application at $125/hectare, is $10,375 or $2.28/tonne.

In summary, the potential silvicultural savings in 2 and 3 could reduce the cost per tonne by $4.05 for a total net cost of $13.49 (delivered cost to Atholville of $39.80/tonne before CREDA reimbursement).

SOFTWOOD RESIDUE PROCESSING

Total cost of the project in 1984 dollars as stated on page 16 is $13,506.32.

As a result of the low production of the trial unit, it is difficult to speculate on reasonable unit costs for processing softwood logging residues.

However, it is clear that an industrial scale system for processing softwood residue must be developed, or alternatively accumulations of the material be burned or concentrated to allow for natural regeneration or plantation establishment.

CONCLUSIONS

HARDWOOD FULL TREE CHIPPING

In terms of meeting the stated objectives to process non-marketable hardwood residue from a softwood logging site, to determine accurate cost data on the operation, as well as to evaluate the logistics and appropriate equipment for an industrial scale operation, the project was termed a success.

A total of 4 557.54 tonnes of hardwood full tree chips were produced for a final cost of $43.85/tonne. At present the cost of hardwood chips is not competitive with locally available sawmill residue. However a number of identified cost factors can be improved upon, and have been as demonstrated by a contractor currently conducting a similar operation on the Fraser Inc. License.

Detailed recommendations and improvements are discussed in the recommendations section.

The importance of conducting an operational scale chipping project on local forest conditions and terrain cannot be overemphasized. Three form, road spcificiations, terrain, and labour rates are different among forest companies and each element has an effect on productivity and cost.

SOFTWOOD RESIDUE PROCESSING

In terms of meeting the stated objectives 'To evaluate, on a industrial scale, appropriate equipment, techniques, and costs of processing roadside softwood logging residue into biomass fuel', the project was partially successful.

The production goals of 8-10 tonnes per hour for a total production of 3 200 tonnes were not achieved. Actual production averaged 1.2 tonnes per hour for a total of 57.05 tonnes. After operating 4 weeks, it was jointly decided between CREDA and Fraser Inc. representatives that all reasonable onsite modifications had been made and that the trial system had been fully evaluated. The final cost delivered to Atholville averaged $236.95/tonne.

A number of design modifications are discussed in the recommendations section.

As a result of the requirements in the Forest Management Manual (Anon 1984) Licensees operating in the Province of New Brunswick are required to burn or remove excessive slash piles and high windrows in order to facilitate either natural or artificial regeneration.

Recovery of the residue and processing into biomass fuel is considered the most attractive alternative in terms of employment generated and value added.

At present, only one type of processing unit (shredder/hammer mill) appears capable of manufacturing the residue into biomass fuel. The high capital and operating costs of this unit are difficult to justify in view of the availability of low cost sawmill residues.

Research and development by manufacturers, forest industry, and governments is necessary to develop lower cost units capable of processing softwood residue into uniform size, shape and moisture content fuel for industrial and institutional use.

RECOMMENDATIONS

HARDWOOD FULL TREE CHIPPING

Equipment Recommendations

1. A larger capacity chipper (30") would have increased production and reduced manual delimbing of tops at roadside, a factor causing unproductive chipper time and increased costs.

2. Highway legal vans as used on the project are not well designed for off road applications. If the hauling could be planned over a private road system, axle loading could be modified to increase traction on the driving wheels.

Logistics and Tree Preparation

1. In Northwestern New Brunswick snow and poor hauling conditions are common in late autumn. If highway vans are used for transport, the operation should be planned to avoid this period.

2. A hot-logging operation, with full trees being felled and hauled directly to the chipper would reduce unproductive moving time of the chipper, and forwarding of trees from the cold deck to the machine. (This technique is currently being successfully used by a chipper contractor working on the Fraser License).

3. Branches on large-topped hardwoods could be partially cut near the upper stem and left attached to the tree. This will facilitate handling and infeed and reduce trimming costs even with a 22" chipper.

4. At the time the project agreement was signed, it was anticipated the material would be hauled to the Edmundston Pulpmill (70 km.). Unfortunately, the chips were hauled to the Atholville Mill (166 km.) due to postponement of trailer dumping facility plans at Edmundston. A 70 km. haul would have reduced transportation costs by $7/tonne.

Administration and Accounting

1. Removal of residual hardwood trees from mixedwood harvest areas permits the establishment of softwood plantations. If 50% of the total roadside cost of full tree hardwood were charged as a silvicultural expense, the cost/tonne would be reduced by $9.64.

2. Payment of full royalty to the Department of Natural Resources ($2.18/$m^3$ hardwood tree length) was required, because of an identified end use for the material.

   It is recommended that royalty rates be reduced to $.50/$m^3$ for all hardwood removal operations for silvicultural purposes regardless if an end use is identified. Royalty reductions will reduce biomass costs and provide more incentive to set up chipping operations. If the royalty cost/m^3 was reduced to $.50/$m^3$ the delivered cost per tonne would decrease by approximately $1.70. If the transportation, accounting and royalty savings are credited to the actual cost of $43.85, the potential delivered cost/tonne would be $25.51.

SOFTWOOD RESIDUE PROCESSING

Equipment Recommendations

As discussed in detail in the Observations During Installation and Monitoring section, the following minimum modifications are deemed necessary to improve production of the trial Morbark Super Beaver unit.

1. Pivoting grapple head with increased power on the self-mounted boom loader to increase mobility and rate of residue transfer to the conveyor.

2. The powered infeed conveyor live surface should be continuous to the chipping disc to prevent plugging of material in the 1 meter long unpowered surface between the disc and conveyor.

3. Steel plate sides on the conveyor should be .5 - 1 meter high at an angle of approximately 60° and continuous to the chipping disc. This modification may prevent tops lodging behind feed rollers, and in holes that currently exist between the conveyor and the chipper.

4. A secondary hydraulically powered fan should improve the discharge distance of lighter material, and permit more complete van loading. A square discharge chute may also reduce plugging. With these 4 modifications, and considering the physical size of the chipper and low weight to volume relationship of the softwood residue, anticipated production is 5 - 6 tonnes per hour.

Material

In spite of the short duration of the project, production improved when operating in fresh softwood residue (delimbed 2 weeks previously). Plugging of the discharge chute was less frequent and moisture content of the material, and subsequent fuel value would be higher. Subsequent operations would be conducted in material delimbed the year of processing.

General

1. Availability of alternative softwood residue processing units in Canada is limited. Prior to selecting the trial unit, attempts were made to rent a drum type chipper or a shredder/hammer mill. The drum type unit was not available for the short trial period in 1984 (planned 3 months), and the rental costs of the latter unit were considered excessive for the short period.

2. Preparation of a standardized glossary of biomass terminology is recommended. Standardized terminology would facilitate communication between suppliers and users in deciding on appropriate equipment. In particular, accurate description and understanding of the raw material would enable suppliers and users to develop more efficient processing units.

INFORMATION TRANSFER

Both the hardwood and softwood chipping projects were high profile, new technology concepts which generated considerable interest within the company, in the community and with other organizations.

Inquiries and visitors to the demonstration projects are as follows:

1. Fraser Open House - October 1983,

   Hardwood Chipping project visited by local press and radio representatives, woodlands staff from other N.B. Licensees, and provincial government representatives.

2. Tour for forest technician students (25) from Ecole Forestière Ville Dégelis, October 1983.

3. Inquiry from the North Shore Forest Products Marketing Board relative to the hardwood phase, and forwarding of preliminary report to that organization.

4. Several sub-licensees of Fraser Inc., and one local woodlot owner visited the hardwood chipper. Follow-up discussions between the woodlot owner and company representatives continued after the project was terminated.

   The woodlot owner decided in 1984 to purchase a similar full tree chipper, operating partially on the Fraser License and supplying chips to a Quebec pulpmill. The Company feels that as a result of the individual observing a production scale operation on local terrain and forest conditions, he felt more confident about purchasing a unit. In addition, in observing and discussing production problems of the project, the private owner was able to develop a more efficient operation.

5. A local hardwood sub-licensee from the St. Quentin region visited the softwood processing project in July 1984, and expressed an interest in evaluating a small roundwood chipper for use on hardwood tops.

6. Two representatives of the Department of Forest Engineering at U.N.B. visited the softwood processing demonstration in August 1984.

ENVIRONMENTAL IMPACT

Implementation of hardwood full tree chipping, and softwood residue processing would yield primarily positive impacts.

Positive environmental impacts may be listed as follows:

1. Removal of hardwood full trees and softwood limbs and tops results in a clean harvest block which may be site prepared with a light patch site preparation implement rather than a plow. Site preparation with a plow results in heavy exposure of mineral soil which can lead to erosion. In addition, resultant heavy competition by scrub hardwoods and raspberries may require up to three applications of herbicide before the plantation is free-to-grow. It is believed that if plantations are established on clean harvest blocks, lightly scarified, that one and at most two applications of herbicides would be sufficient.

2. In the past, plantations were often established beneath a sparse poor quality residual crop of hardwoods. Subsequent herbicide applications to control the ground level undesirable competition also resulted in death of the overstory residuals. This is a controversial method which resulted in public criticism.

3. Removal of roadside accumulations of spruce and fir branches and tops reduces fire hazard and improves aesthetic appearance of the harvested area.

4. Accumulations of spruce and fir branches and tops from delimbing occupy an area approximately 8 to 10 meters wide, and more or less continuously along both sides of logging roads. Clearly, this area will not regenerate naturally during the rotation of the adjacent harvest block, nor can the land be planted without removal or concentration.

A potentially negative long term impact is the removal of all woody material including foliage from the harvest area which may result in reduction of nutrients in the soil. Several studies have evaluated this impact and the concern is primarily in well drained sandy soils, where nutrients may percolate out of the soil and not be replaced, due to the lack of decaying organic matter. However, the soils on Fraser Crown Land and Freehold are primarily loams on which the long term reduction in nutrients is not expected to be serious.

FULL TREE CHIP TRIAL
AT FRASER INC. ATHOLVILLE PULPMILL

The objective of the trial was to compare hardwood chip handling, storage and burning with softwood sawmill waste.

Chips were hauled and piled down at the Atholville mill from October 4 to November 22, 1983, and usage trials were conducted on April 16-19 and April 30-May 2, 1984.

Some observations of the trials are:

- steaming, charring, and exudation of black resin (shellac) occurred in the outside inventory pile.
- ignition occurred on April 13 when the air temperature was high.
- the average moisture content (mc) of hardwood chips as delivered was 40%, however, the top surface chips (0-1 meter down) increased to 54%. The interior chips, because of heating dried to 36% mc.
- chips were stored in a pile 8 meters high, 27 meters across the top and 55 meters across the bottom.
- the average chip produced was 2.5 x 2.5 x .6 cm, with a quantity of fines and branches of 1 x 3 cm.
- hardwood chips were more difficult to remove from the pile than sawmill waste as a result of the chips and branches forming a mat.
- when the pile is frozen, overhangs of frozen chips to 1.5 meters long resulted at the edge of the pile. These lumps had to be physically broken with the loader bucket.
- large frozen lumps of chips caused plugs and damage to the conveyors.
- branches mixed with the chips caused plugs in the fuel distributing conveyor, however, this can be solved with modifications.
- a lower ash content was found with burning hardwood chips relative to softwood sawmill waste. As a result, less downtime was required to clean the boiler combustion grates.
- hardwood chips were found to have a good retention time in the boiler and most of the burning particles burned out completely before leaving the boiler.

- hardwood chips were found to be less contaminated than sawmill waste (Broken pieces of steel from sawmill machinery often clog the clinker crusher).

- a number of equipment modifications were recommended by the mill engineers, and it was also suggested that;

  1. Hardwood chips be stored no longer than 30 days to prevent fires and excess soaking.

  2. As much as possible the loader operator remove lumps of frozen chips.

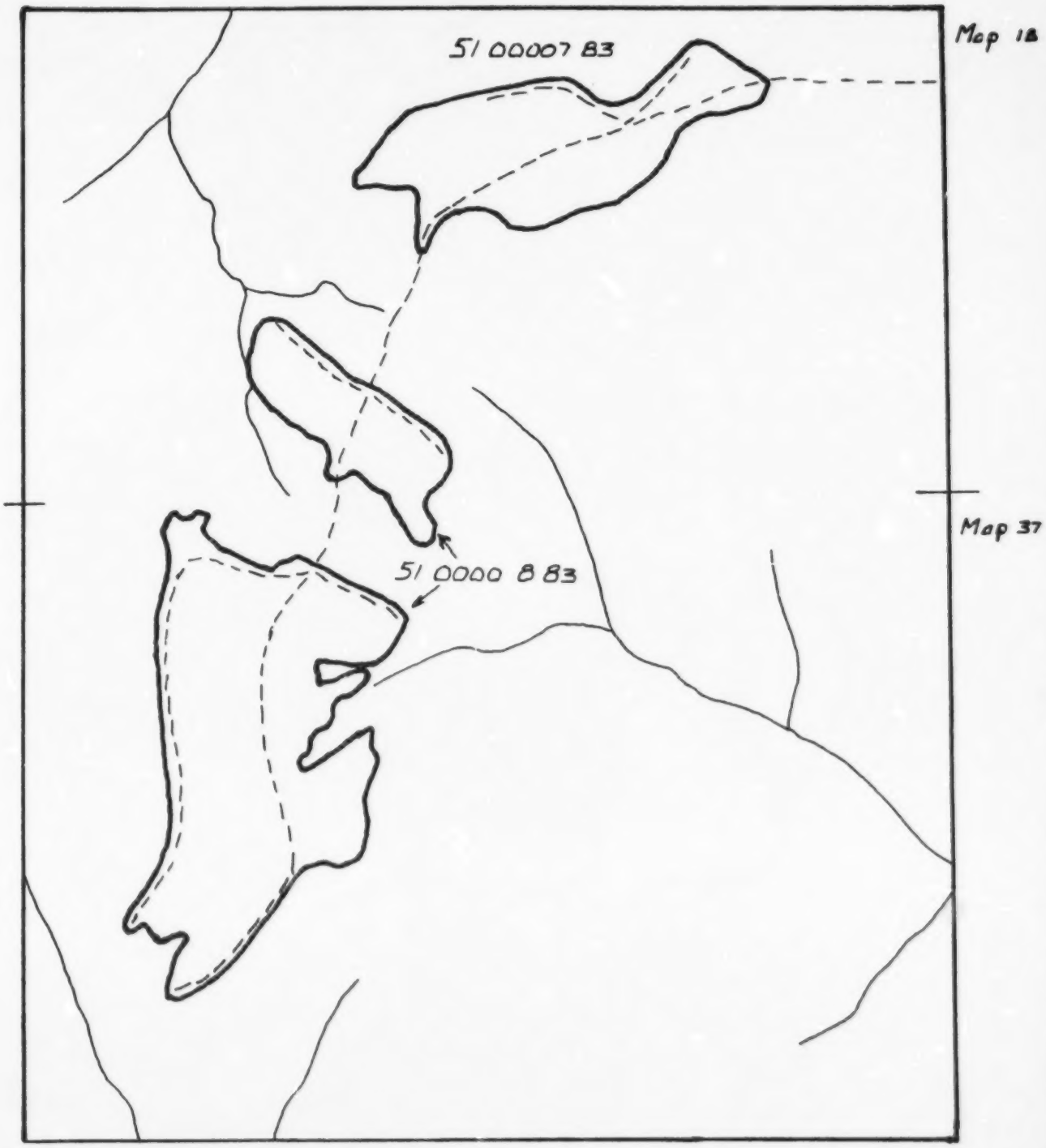
- Full tree hardwood chips were found to be an all around superior fuel to softwood sawmill waste.

Refer to Appendix III for the detailed chip trial analysis.

APPENDICES

APPENDIX I

1:20000 BASE MAP LOCATION OF
HARDWOOD FULL TREE CHIPPING TRIAL (1983)



APPENDIX II

1:20000 BASE MAP LOCATION OF
SOFTWOOD RESIDUE PROCESSING TRIAL (1984)

Scale: 1:20,000

APPENDIX III

HARDWOOD CHIP TRIAL ON NO. 8 BOILER

IN ATHOLVILLE

Date: April 16 - 19, 1984, April 30 - May 2, 1984.

Done by: Larry MacLaggan

Objective: To compare Hardwood Chip Handling, Storage and Burning with Softwood Sawmill Waste.

Summary:

During the 7 days of Hardwood Chip Trial, there were only 3 days satisfactory operation due to no steam load or plugs in the equipment. In spite of this, valuable information was received as follows:

The chip storage pile is steaming and igniting due to the pile heating up. The chips have steamed out and caught on fire (charred) in certain places as there was a fire in the pile on April 13. Temperature affects the chip pile as it steamed all winter but only ignited on a warm day April 13. A black sticky resin (Shellac)saturates the surface of the chips in these areas where burning and heating is taking place. This resin and water drips (visible) down through the pile and runs out on the asphalt.

The chip pile stands vertical being dry and unfrozen in the interior. The top 1-1.5m overhangs severely being frozen and wet.

Large and medium size frozen lumps of Hardwood Chips must be smashed or removed by the loader operator as these cannot be processed by the present equipment.

Hardwood chips plugged the fuel distributing conveyor more often than Sawmill Waste because the supply trough was not deep enough. (This has been temporarily corrected). The Hardwood chips which were stored outside over the winter for 6 months (originally approx. 40% Mc) wetted to 54% Mc in the top surface of the pile, but dried to 36% Mc in the interior.

The operators prefer Hardwood Chips over Sawmill Waste as burning and ash removal are better. Plugs in conveyors and chutes cause most of the handling problems but this can be corrected by equipment modifications.

The equipment recommendations section of this report covers obvious visual equipment problems and is not intended to be a complete list of modifications required. All other equipment not mentioned appears to be operating satisfactorily.

Source:

Hardwood trees on the Company's Woodlands were chipped and delivered late in the fall of 1983, therefore the material consists of mostly 2.5 x 2.5 x 0.6cm chips along with fines and branches 0.9 x 20 cm. There are very few pulpwood size pieces.

Sawmill waste is delivered from a number of local Sawmills including our Kedgwick Mill, therefore the material consists of sawdust, fines, bark and pieces of wood.

Appendix III - cont'd

Storage:

The chips are stored in a pile 25 ft. high, 90 ft. across the top and 180 ft. across the bottom. The pile was built by a loader and is therefore very well compacted. The chips pile at approx. 45°.

The chips have steamed out and caught on fire (charred) in certain places as there was a fire in the pile on April 13. Temperature affects the chip pile as it steamed all winter but only ignited on a warm day April 13.

Chips are slightly harder to dig out with a loader than Sawmill waste due to the chips and branches forming a mat. This matting makes it possible to dig a tunnel in the pile, but due to its large size the loader can break this mat to give a vertical face.

Chips form a vertical face up to 23 ft. when they are dug from the bottom with a loader. The top 2 - 4 ft. is frozen and overhangs so that the loader must push from the top of the pile. The outside 1 1/2 ft. is very wet, the next 2 1/2 ft. is damp and the interior is surface dry due to the rain shedding effect of the chip pile.

	Moisture Test Results from Hardwood Chip Pile					
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Average
Top Surface (24 ft.)	58.8	46.2	52.4	58.6	56.4	54.5
12 ft. from bottom	25.8	30.3	39.9	53.2	33.0	36.4
3 ft. from bottom	23.6	30.0	34.2	45.8	50.0	36.7

A large section of the core of the pile has charred severely and it appears to originate in the Sawdust portions of the core.

Handling:

1. Large frozen lumps of chips damage and plug the conveyors and chutes therefore the loader operator must break them up by driving over them or banging them with his bucket. The biggest problem occurs when medium size lumps cause a plug of nail scalper by sitting between the disc rolls.

2. Short roundwood pieces in the Sawmill Waste build up ahead of the infeed hopper gate and form a bridge 6' thick causing lost production. Pieces of wood sit between the discs on no. 1 Scalper causing plugs.

3. All chips fall through the no. 2 Scalper (1" clearance) before the 6th disc during a normal flow of material. A slug of material will cause approx. 20% of the chips to carry over into the shredders. Approx. 3/4 of the branches and 5% of the total material go over no. 2 Scalper into the shredders. The slope on the shredder infeed chute is too flat as oversized material hangs up on the chute.

4. Chips plug at the bottom of the shredder discharge chute and the bottom of the no. 2 Scalper accepts chute because slugs of material that had built up ahead of the magnet plug between the shredder discharge conveyor and the chute bottom. (See Equipment Recommendations).

5. The Scalper no. 1 Feed Conveyor shows a 1:6 feed ratio because of the intermittent feed from the infeed hopper. The Process Building Feed Conveyor shows a 1:2 feed ratio and the Boiler Building Feed Conveyor shows a 1:15 feed ratio. Therefore multiple transfers and screens even out slugs in the system. The flexowall conveyor shows a 1:3 feed ratio due to the eneven feed of the storage bin stokers.

6. Branches in the chips (40% branches, 60% hogged & screened) plug the fuel distributing conveyor because the clearance between the top of the wooden flight and the nearest obstruction is only 3". During a normally even run of chips a plug will occur because chips mound up in front of the flight and jam. See equipment recommendations for problem solution. The fuel distributing conveyor plugs every week on Sawmill Waste but plugs every day on Hardwood Chips. (CORRECTED).

7. Branches tend to fall out of the flexowall conveyor pockets as they are longer than the pocket width.

8. The storage bin stokers push chips ahead very well with only a partial bridge forming infrequently against the discharge beam. This bridge starts at both sides of the bin arching up toward the center, but leaves the middle 1/4 of the bin unbridged.

Boiler:

1. Only the lower 6-10 ft. of the steep sloping portion builds up with Hardwood Chips therefore not allowing proper drying. Approx. 1/2 of the chip material hits the material already in the drying section and pops over onto the burning portion of the grate with no drying whatsoever. Chips that remain in this section are dried. Operators say that Sawmill Waste has built up before to completely fill the steep sloping section and plug a rotary feeder. (This happened once with Sawmill Waste during the Hardwood Trial).

2. There is a good retention time in the boiler because many of the burning particles (sparklers) have time to burn out completely before they leave the furnace. Many of the particles enter the fire ball twice due to swirling air currents above the grate.

3. Chips build a good bed during start-up much faster than Sawmill Waste (3 min. compared to 15 min.) but operate with much less bed than Sawmill Waste (4 in. compared to 2 ft.)

4. Grate cleaning takes approximately 30 min. with chips as compared to 1-2 hrs. with Sawmill Waste and the operators are very pleased. This could be due to operating with less bed or that chips have not been burnt for more than 12 hrs. consecutively. The ash from one cleaning after only Hardwood Chips were burnt contained 10% ash, 45% clinker and 45% gravel in a 4" thick mat on the grate. (The steam jets might have removed much of the ash).

5. There is a fair amount of glowing embers at the superheater tubes but no glowing embers at the fly ash hopper (charr. tank). There were approx. 36 in^3/min. of ash falling out the fly ash hopper while the load on the boiler was 1100 MTPD from bark.

6. The boiler ran 20 min. on automatic at design with a stable load, a very good fire and the following results:

Total Steam = 1620-1650 MTPd
Steam from Bark = 1400-1440 MTPd
Steam from Oil = 220 MTPd (1 gun, oil on min.)
I.D. speed = 76%
F.D. speed = 85%
Furnace Draft - .08 - .15 Negative KPa
Bark Feeders = 1.7 RPM
O_2 = 6%
Fuel = Hardwood Chips tumble down the steep slope with the light particles going directly into the air and flash burning. One half of the heavier material stays on the drying section which is only built up 6-10 ft. while the other half hops over into the fire immediately. Many of the sparklers (burning chips) leave the fire ball at the overfire air nozzles, recirculate down and re-enter the fire ball, being burnt completely. The bed in the burn area is approximately 4" thick and it boils with excellent air penetration fairly evenly distributed. There is a large build up on the bed at the change in slope between the drying and burning sections.

Equipment Recommendations:

Store hardwood chips no longer than 30 days to prevent fires and excess soaking.

Specific equipment recommendations are considered confidential, and as such not released.

APPENDIX IV

VALUE OF HARDWOOD FULL TREE CHIPS AND SOFTWOOD RESIDUE AS COMPARED TO OIL

The following is a direct comparison of energy equivalents only, and no attempt has been made to account for the capital costs or operating costs associated with oil burning or hog fuel burning.

1. Assumptions

a) Boiler Efficiency: oil = 83%
hogfuel = 73.5%

b) 1 dry tonne hog fuel: 19.773 G.J. (Giga Joules)

Average moisture content of hog fuel when burned: 45%

1 green tonne hog fuel @ 45% M.C. = (1 - .45) x 19.773 G.J.
= 10.875 G.J.

Less the energy required to vapourize the water (assume wood at 70° F)

Heat required: (1 btu to heat 1b of water 1° F)

= (212°F - 70° F) X (0.45) (2200 lbs)

= 139,700 BTU

Latent heat of vapourization

= (970 BTU/1b) (2200 lbs) (0.45)

= 960,300 BTU

TOTAL = 1,100,000 BTU (1.16 G.J.)

1 Green ton = 10.875 G.J. - 1.16 G.J.

= 9.715 G.J.

c. 1 barrel bunker "C" oil: 6.647 G.J.

d. 1 barrel oil: $34.28

2. Chip Harvester Hog Fuel

1 green tonne = .735 (efficiency) x 9.715 G.J./green tonne

= G.J./green tonne

= 7.14

3. Bunker "C" Oil

1 barrel = .83 (efficiency) x 6.647 G.J./barrel
= 5.52 G.J./barrel

4. Oil Equivalent of Hog Fuel

1 green tonne (45% M.C.) = 7.14 G.J./green tonne

1 barrel bunker "C" - $\frac{5.52 \text{ G.J./barrel}}{1.3 \text{ barrels/green tonne}}$

5. Value of Hog Fuel

1 green tonne (45% M.C.) = $\frac{1.3 \text{ barrels oil}}{\text{Green tonne}}$

= $44.57 green tonne

Although the energy equivalent of biomass at $44.57/green tonne is greater than the $43.85/green tonne delivered cost, as indicated above, capital and operating costs of the two systems were not compared. Handling costs with biomass systems are significantly higher than with oil. In addition a large inventory of biomass must be maintained to compensate for the seasonal shut-down of woodlands operations. Inventory and handling costs of hardwood full tree chips are estimated at $10 per tonne.

Boiler efficiency in Assumption 1.a) has not yet been substantiated.

A local supply of sawmill residue is currently available to both Fraser pulpmills at less than $10/tonne delivered.

APPENDIX V

LIST OF AVAILABLE PHOTOGRAPHS

HARDWOOD FULL TREE CHIPPING

Photo Number	
1 - 4	Full tree hardwood at roadside demonstrating characteristic branching.
5	Hardwood logs removed prior to chipping (Piled on opposite side of road).
6, 7	Forwarding of full tree hardwood from cold deck to chipper with a grapple skidder.
8 - 10	Infeed of thin-crowned white birch from cold deck directly into chipper.
11	Manual trimming of wide crown trees at the chipper.
12	Chipper/van allignment at the work site.
13	Hardwood full tree chip pile, off-loading, and infeed systems at Atholville Mill.
14, 15	Steaming of hardwood full tree chip pile.

SOFTWOOD RESIDUE PROCESSING

16	Powered infeed conveyor prior to modification.
17 - 19.5	Infeed conveyor modified with welded traction bars.
20, 20.5	Forwarding softwood residue with a Morbell directly to the infeed conveyor.
21	Plug of material between the end of infeed conveyor and chipping disc.
22	Chipper operator reclaiming fresh residue from the surge pile delimbed 2 weeks previously.
23,24,25	Discharge of softwood residue into highway vans, with pile of lightweight material forming in foreground.
26	Non pivoting grapple head fitted to the Super Beaver Boom Loader.

APPENDIX VI

REFERENCES

ANON (1984) - Forest Management Manual for Crown Lands. Department of Natural Resources, Province of New Brunswick, May 1984.